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FOUR UNDERUTILIZED

COLLISION REDUCTION MEASURES

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ABSTRACT

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Hamilton, like other Canadian cities, carries on an active vehicle collision countermeasures program. Many of the countermeasure techniques, such as conversion of streets to one-way operation, use of standard warning and regulatory signing, and standardization of traffic signal design and operation, are in widespread use. However, experience in Hamilton has shown that there are four proven countermeasures which are exceptionally effective in reducing traffic collisions, and which may not be aggressively exploited on a broad scale in many municipal jurisdictions, and documentation of the effectiveness of these measures is either unavailable or else has not been widely disseminated.

The first countermeasure is the removing of parking from arterial streets, primarily for reasons of safety. Hamilton has a policy of removing parking from all arterial streets, which began in 1968. This program has been applied to 87 percent of the street system, with the result that collisions on these streets have been reduced by 37 percent, and other obvious advantages have been gained.

The second countermeasure is the control of all four-leg intersections within residential neighbourhoods by two-way stop control, in a comprehensive and strategic pattern. This program is now completed, and has resulted in a reduction of collisions of approximately 48 percent, at intersections where the control was changed, and 24 percent for all neighbourhood collisions, as well as the provision of other traffic management capabilities.

The third countermeasure is a program to provide intersection channelization and left turn lanes at all arterial intersections as a safety measure, rather than on the basis of capacity alone. This program has been active since 1965, and approximately 51 intersections have been channelized since that time. The resulting reduction in collisions at each intersection is approximately 55 percent.

The fourth countermeasure is the provision of two-way left turn lanes on commercial arterial streets, with a resulting collision reduction of 49 percent.

Implementation of these measures began in 1965, and has resulted in a steadily declining collision rate in Hamilton, to the point where Hamilton is one of the safest cities in Canada and in North America, as is documented by traffic collision statistics. This paper presents documentation of the effectiveness of these countermeasures, design detail and implementation strategies.

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1. INTRODUCTION

Motor vehicle collisions continue to exact a high toll of human and economic resources in urban areas, despite the constant efforts of highway planners, vehicle and roadway designers, roadway operators, driver training instructors, legislators and enforcement officials. J. J. Lawson, in an excellent paper entitled "The Cost of Road Accidents and Their Application in Economic Evaluation of Safety Programs", estimated that the average cost of a motor vehicle collision in Canada, in 1978, was \$4,500.00 for the basic direct costs of property damage, lost productive work and health care costs, only. Not included in this figure were the costs of police and other emergency services, legal and court proceedings, administration of legal claims and replacement vehicle, not to mention the incalculable cost of pain, suffering and mental anguish. It is safe to say that inflation has increased these basic costs to an average figure of at least \$6,500.00 per collision, in 1982.

As an example of the economic impact of traffic collisions on a typical urban municipality, the total cost of the estimated 7,000 reported collisions which will occur in the City of Hamilton in 1982 is 45.5 million dollars, or an average of \$148.00 for every man, woman and child in the City. This figure does not include the costs of the unreportable and unreported collisions, which probably equal or exceed the number of reported collisions. Also, there is evidence that Hamilton is one of the safest municipalities in North America, for cities within the same population range.

Data from Statistics Canada "Vital Statistics, Volume III, 1976" publication reveals that the accidental death rate in Canada for traffic accidents of 22.2 deaths per 100,000 persons, almost equals the total rate of all other causes, including fires, drowning, industrial accidents, poisoning, other transport, firearms and all other deaths, of 26.8, as indicated in TABLE 1.

All major urban municipalities in Canada are engaged, to varying degrees, in programs of accident analysis and countermeasures. The basic tools of improved roadway designs, street lighting, pavement marking, signing, standardization of traffic signal design and operation, and implementation of one-way street systems have been used, with varying degrees of resources and determination, and very likely, with varying degrees of success.

In addition to employing the standard collision countermeasure techniques and remedies on a site-specific and individual basis, the City of Hamilton has attacked the problem on a broad based and systematic basis for several years. In particular, comprehensive programs have been pursued in relation to three specific measures, which are: the prohibition of parking on all arterial streets; the implementation of two-way stop control at all four-leg local street intersections within neighbourhoods; the systematic widening and channelization of the intersections of arterial streets. A fourth measure, which is the provision of two-way left turn lanes on arterial streets, is also now being actively exploited. This paper documents the encouraging results of these programs, in reducing the collision rate in the City of Hamilton.

2. PROHIBITION OF PARKING ON ARTERIAL STREETS

2.1 The Concept

This program involves the adoption of the principle of ultimately prohibiting parking from all arterial streets in the urban municipality, on a full-time basis. The term

ACCIDENT CAUSE	Number of Deaths	Death Rate per 100,000	Percent of Total
Traffic Accidents	5,110	22.2	45.3
Accidental Falls	1,820	7.9	16.1
Fires	765	3.3	6.7
Drowning	731	3.2	6.5
Industrial	672	2.9	5.9
Accidental Poisoning	526	2.3	4.7
Other Transport	520	2.3	4.7
Firearms	89	0.4	0.8
Motor Vehicle (non-traffic related)	62	0.3	0.6
All Other	956	4.2	8.6
TOTAL	11,251	49.0	100%
TABLE 1 - CAUSES OF ACCIDENTAL DEATH IN CANADA			

"arterial street" is used, on a very loose basis, to include all streets which are part of an appropriate network of streets of which the primary function is or should be to accommodate relatively long distance movements within and through the municipality, rather than to provide a local land access or local collector function. This definition is a functional definition, rather than a current volume definition, and therefore the arterial street system so defined, will remain relatively unchanged as increasing development and traffic generation occurs in various areas of the municipality.

Although some parking prohibitions had been enacted many years ago in Hamilton, the main thrust of the program began in 1968, and is presently continuing. The current status of the program is that, to date, of the 238 kilometres of arterial streets, parking has been removed from both sides of 206 kilometres (87%) and from one side of 24 kilometres (10%) of the total arterial street system. The extent of progress in Hamilton is illustrated in FIGURE 1.

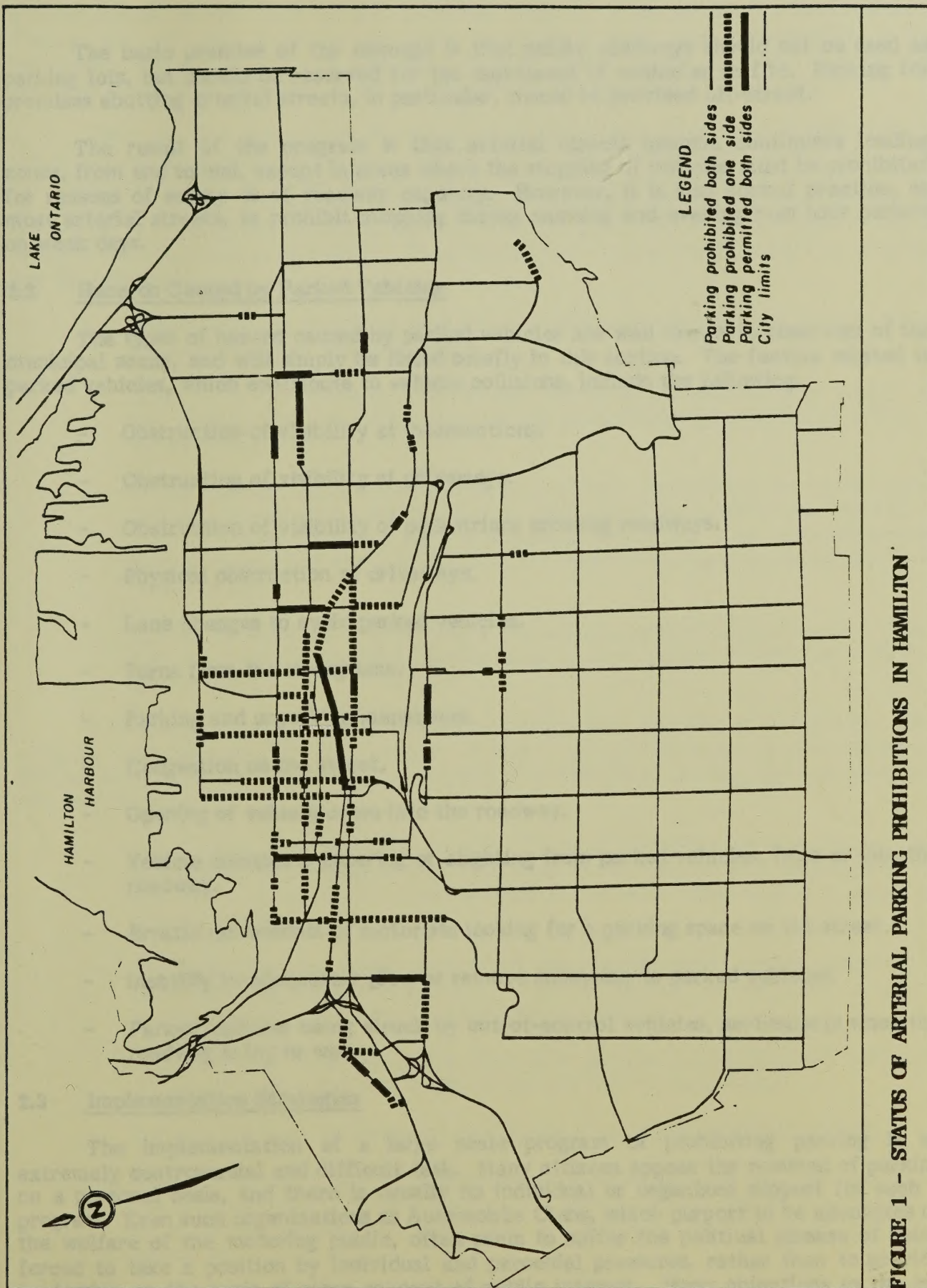


FIGURE 1 - STATUS OF ARTERIAL PARKING PROHIBITIONS IN HAMILTON

The basic premise of the concept is that public roadways should not be used as parking lots, but should be reserved for the movement of vehicular traffic. Parking for premises abutting arterial streets, in particular, should be provided off-street.

The result of the program is that arterial streets become continuous loading zones, from end to end, except in areas where the stopping of vehicles must be prohibited for reasons of safety or of roadway capacity. However, it is also normal practice, on most arterial streets, to prohibit stopping during morning and evening rush hour periods on week days.

2.2 Hazards Caused by Parked Vehicles

The types of hazard caused by parked vehicles are well known to observers of the municipal scene, and will simply be listed briefly in this section. The factors related to parked vehicles, which contribute to vehicle collisions, include the following:

- Obstruction of visibility at intersections.
- Obstruction of visibility at driveways.
- Obstruction of visibility of pedestrians crossing roadways.
- Physical obstruction of driveways.
- Lane changes to avoid parked vehicles.
- Turns from the wrong lane.
- Parking and unparking maneuvers.
- Congestion on the street.
- Opening of vehicle doors into the roadway.
- Vehicle occupants entering or alighting from parked vehicles, from or into the roadway.
- Erratic movements of motorists looking for a parking space on the street.
- Inability to adequately plow or remove snow, due to parked vehicles.
- Parked vehicles being struck by out-of-control vehicles, particularly when the roadway is icy or wet.

2.3 Implementation Strategies

The implementation of a large scale program of prohibiting parking is an extremely controversial and difficult task. Many citizens oppose the removal of parking on a personal basis, and there is usually no individual or organized support for such a program. Even such organizations as Automobile Clubs, which purport to be advocates of the welfare of the motoring public, often seem to suffer the political disease of being forced to take a position by individual and parochial pressures, rather than to provide leadership on the basis of some concept of public interest. Many objections to the removal of parking are based on resistance to change, which is an inherent trait of the

general public. Other more specific concerns range from the almost inconsequential ... ("where will my uncle park his car when he comes to visit next Christmas?"), to the legitimate concern ... ("where will my customers park?"). For whatever the reasons might be, the traffic engineer often stands alone in promoting this type of program.

There are four basic types of implementation strategy which must be addressed by the implementer of such a program. The first of these is a philosophical strategy. The traffic engineer must first sell his program to the decision makers, and to some segments of the general public. While the selling strategy should be done on a broad comprehensive basis, it is likely that initially, survival of the program will be on the basis of implementation of "one street at a time". The principle elements of the philosophical strategy are the following:

- Public highways should be used for the movement of vehicular and pedestrian traffic, and not as parking lots.
- There is no such thing as free parking. Someone has paid for or is paying for the construction and maintenance of the public highways, and that someone is the general public.
- In commercial areas, where off-street parking is inadequate, on-street spaces should be metered to provide revenue, until such time as off-street lots can be provided. Customers will pay for parking if they must. Also, metered parking gives a measure of the true demand, for commercial parking, as distinct from "free loading".
- Parking on arterials is often only a convenience rather than a necessity. Thus, the trade-off is personal convenience against public safety and efficient traffic flow.

The second type of implementation strategy is a preparational strategy. The program must be planned over a number of years, and certain types of preparation lay the groundwork for successful implementation at a later date. Among these preparations are the following:

- The Zoning By-law should require adequate off-street parking for all land uses. Motorists prefer to park off-street rather than on busy arterial streets, and where adequate off-street parking is available, implementation problems will be minimal.
- Prohibition of over-night parking on the arterial street forces motorists to find other parking accommodation. Arterial parking for residential uses then becomes only a convenience, rather than a necessity.
- Prohibition of stopping during rush hour periods forces residents and merchants to make other provisions for parking during these hours.
- Reverse frontage development eliminates all need for on-street parking.
- The installation of parking meters relocates those who are not prepared to pay for their parking. To some extent, the parking meter may be the equivalent of a parking prohibition, and make the ultimate removal of parking more palatable.

The third type of implementation strategy is an informational strategy. Information is needed to thoroughly document the present parking demand, the available alternatives to on-street parking, and the need for off-street parking. Information is needed also to refute the many inaccurate claims and submissions which will be made by opponents of the program. Most opposition occurs immediately following the implementation of parking prohibitions, although with public participation becoming more in vogue, earlier opposition might be expected in the future, by a better informed and more militant public. The types of information which should be available, when public debate takes place, include the following:

- An assessment of the need to remove parking in the future for reasons of capacity, rather than of safety alone, should be made. Decision makers and merchant groups can often be persuaded that the program of providing off-street lots should begin in advance of the final time of crisis.
- The fact that off-street lots provide full time parking for merchants, uninterrupted by rush hour or over-night parking prohibitions, should be made clear to decision makers and merchants.
- Frequently, residential and commercial parking needs can be provided off-street by the abutting owners, simply by paving available lands, providing driveway accesses, or reducing landscaped areas. All existing and potential parking spaces for each individual premises should be thoroughly documented.
- The potential for parking on side streets should be documented. Visitor parking for low destiny residential uses can usually occur on side streets in front of other residential uses, without generating complaints. Commercial flank-ages on side streets can often be metered, to remove long term parkers and to make space available for short term commercial parkers, who are willing to pay for the privilege.
- The actual demand for on-street parking should be documented, so that it may be compared with the existing and potential off-street and side street supply. Studies should include the hours of peak parking demand, which may be week-day, evening or Saturday, depending upon the type of land use involved.

The fourth type of implementation strategy is the political strategy. This element is based on recognition of the fact that the elected decision makers win elections on the basis of short term satisfaction of immediate demands by voters, rather than lofty and idealistic long range concern for what is sometimes a somewhat nebulous concept of public interest. This strategy is meant to minimize adverse pressures on the elected representatives to such a degree that they can, with a little courage, support the traffic engineers program. Some of the elements of this strategy are the following:

- Implement the least controversial regulations first. These apply to the arterial streets in outlying areas where there is presently no development, and from which there will be no objection. Proceed to other streets on the basis of anticipated opposition.
- Implement large sections at a time. Pass by-laws on a sweeping scale, and implement large sections of individual streets, one at a time.

- Leave intervals between subsequent signing activities so that only a few objectors are vocal at any given time.
- Erect signs quickly in each section, so they are up before complaints can begin. Use several sign crews to complete the job in one or two hours, if possible.
- Do not erect signs before the Christmas commercial season in November or December.
- Do not erect signs before holidays or long weekends, when many residents are expecting out-of-town guests with cars.
- Do not erect signs in the six or eight month period prior to Municipal elections, when elected representatives are under extreme pressure.
- When opponents appear before Committees, determine what their complaints are and re-study each specific complaint to document validity or lack of validity. Study it to death, and sidetrack precipitous action by the Committee. Seek alternatives to answer each and every specific complaint.

Thus, implementation strategies begin long before parking prohibition signs are erected, and sometimes continue long after, as rear-guard actions to retain the regulation in spite of the opposition which may materialize.

2.4 Other Benefits of Parking Prohibitions

In addition to reducing collision rates, there are many other benefits from prohibiting parking on arterial streets. Among these added benefits are the following:

- Increased roadway capacity is achieved by utilizing all lanes for moving traffic.
- Total capital expenditures and maintenance costs are minimized by full utilization of the existing system.
- Transit service is very much enhanced, and operating costs are reduced, when curb lanes are unencumbered by parked vehicles.
- A better level of service on the arterial system results in lower volumes through residential neighbourhoods.
- Loading operations are much easier, and cost of goods movement and deliveries is minimized.
- Streets are generally clearer of parked vehicles during rush hour periods, since failure to see the rush hour signs, and unexpected delays for parkers, and vehicles which will not start, are no longer a significant problem.
- Improved street maintenance operations, including snow plowing and removal, result in reduced costs and increased efficiency.
- The general appearance of the streetscape is improved.

2.5 Effect on Collisions in Hamilton

A sample of arterial streets in Hamilton, from which parking has been removed, has been selected for a "before and after" analysis of the effect on the collision rate of prohibiting parking. The selection was based upon an attempt to analyse typical and representative street sections, and also to select street sections where the parking was removed for a significant distance at one time, such that before and after analysis would be straightforward. The sections selected for analysis were all in areas of the City where full development of the abutting lands had occurred.

An analysis of the collision rates for the selected street sections is presented in TABLE 2. The collision rates computed include all collisions in the street section, exclusive of signalized intersections.

The reduction in collision rates for the six sample street sections ranged from 20 percent to 54 percent, and the average reduction was 37 percent.

3. STOP CONTROL OF LOCAL STREET INTERSECTIONS

3.1 The Concept

This program involves a systematic review of all developed neighbourhoods within the Municipality, with the objective of implementing two-way stop control of all four-leg local street intersections, as a general rule. While the program should be applied to all neighbourhoods, the most sweeping application is in the older grid pattern street systems, where there was no intended street hierarchy of local and collector streets, when the streets were laid out many years ago.

At one time, a prominent school of thought respecting the use of stop sign control at intersections was based on the premise that motorists should not be required to stop at an intersection unless a relatively serious collision problem had been documented. One example of the criteria used by this approach was that no control should be used at local street intersections unless they were experiencing three collisions per year, at which point yield signs could be erected. Stop signs were not warranted, under these criteria, unless there were at least five collisions per year at the intersection. Also, the rule was that the yield or stop signs should be erected strictly on the street carrying the smaller volume of vehicular traffic. Rigid criteria such as these would seem to have fallen into disfavour in recent years, in many jurisdictions.

One basic premise of this program is that through traffic should not travel through residential neighbourhoods. In addition to serving the primary function of allocating right-of-way at intersections, the strategic use of stop signs can be effective in a neighbourhood traffic management scheme.

A second basic premise is that it is not a hardship for a resident to stop as many as three or four times within his own neighbourhood, as long as most of his trip is accommodated on an efficient arterial system.

The program in Hamilton has consisted of reviewing all of the developed neighbourhoods in the City, and controlling virtually all four-leg intersections by two-way stop control. This has required the removal of yield signs in many cases, and a change in direction of stop control in other cases. The policy respecting T-intersections has been to not control them unless there is some evidence of a collision record or some abnormal physical feature or visibility obstruction.

STREET	LENGTH (km)	YEAR PARKING REMOVED	BEFORE (3 YEARS)			AFTER (3 YEARS)			CHANGE IN COLLISION RATE
			COLLISIONS	AWDT VOLUME	COLLISION RATE *	COLLISIONS	AWDT VOLUME	COLLISION RATE *	
<u>Upper Wentworth</u> - Mohawk to Fennell	1.03	1969	19	3,660	4.8	9	3,860	2.2	- 54%
- Fennell to Crockett	0.75	1969	38	4,410	11.0	19	4,610	5.2	- 53%
<u>Fennell</u> - U. Gage to U. Kenilworth	1.71	1968/69	76	7,850	5.4	58	9,600	3.4	- 37%
<u>King</u> - Walter to Parkdale	0.43	1975	40	20,560	4.3	30	21,600	3.1	- 28%
<u>Parkdale</u> - Barton to Brampton	0.84	1973	76	16,180	5.3	62	18,910	3.7	- 30%
<u>Main</u> - Delta to Strathearne	1.90	1970	477	20,180	11.9	463	24,370	9.5	- 20%
AVERAGE									- 37%

* Collision Rate per million vehicle kilometres = $\frac{\text{accidents per year} \times 2,860}{\text{distance (km)} \times \text{A.W.D.T.}}$

TABLE 2 - COLLISION RATES ON ARTERIAL STREETS AFTER PARKING IS REMOVED

The neighbourhood analysis procedure in Hamilton followed the following steps:

- An idealized pattern of stop control was determined, based upon requiring the motorist on a street in a local street grid to stop at two block intervals. The idealized pattern was developed having regard for the existing pattern of stop control, if there is one, such that the incidence of reversing the direction of stop control may be minimized. In cases where a local street is or will be signalized at an arterial or collector street at the perimeter of the neighbourhood, stop signs on the local street are placed no closer than 300 metres from the traffic signal to avoid an overlapping area of influence, and therefore a conflict between the two devices.
- All intersections are surveyed on-site to verify that visibility and other conditions in the field will allow the idealized signing pattern to be implemented. It is frequently found that portions of the idealized pattern must be changed at intersections where visibility or other factors are abnormal. It is necessary not only for the stopped motorist to be able to see traffic approaching on the intersecting street, but also for the stop signs to be visible and effective for approaching motorists. In some cases, it was found that it was necessary to have visibility obstructions, such as hedges or shrubbery, trimmed or removed.
- The idealized pattern was adjusted, as required by field conditions, and then implemented.

An example of changes made in a typical residential neighbourhood is presented in FIGURE 2.

3.2 Implementation Strategies

The intersection control program is generally supported by the public, since it is perceived by most local residents to be a safety measure to modify driver action and to improve residential amenities. The principle source of complaint stems from the reversing of the direction of existing stop sign control, or replacing yield signs on one street with stop signs on the intersecting street. The nature of citizen complaint is generally that the speed and volume of traffic has increased on the street which was formerly controlled by stop or yield signs at a certain intersection. In Hamilton, various site-specific studies have failed to substantiate these claims, since the overall effect of increasing stop sign control on a comprehensive basis is to discourage through traffic and excessive speed. Nonetheless, the rate of speed on intersection approaches will be modified by changes in stop sign control, in the area within 30 or 40 metres of the intersection.

The best defence against subjective statements by individual residents is before and after studies of intersections where the direction of control is to be reversed. Traffic counts should be taken at strategic locations to document the magnitude of change in traffic volume. Speed studies should be conducted at locations at least 30 metres away from the intersection, to measure general speed characteristics rather than speeds at the intersection.

A secondary defence is a general documentation of typical vehicular volumes on local residential streets in the Municipality, in order that factual data may be presented as to whether or not the volume on a specific street exceeds a typical volume for other local streets in that area and in the Municipality.

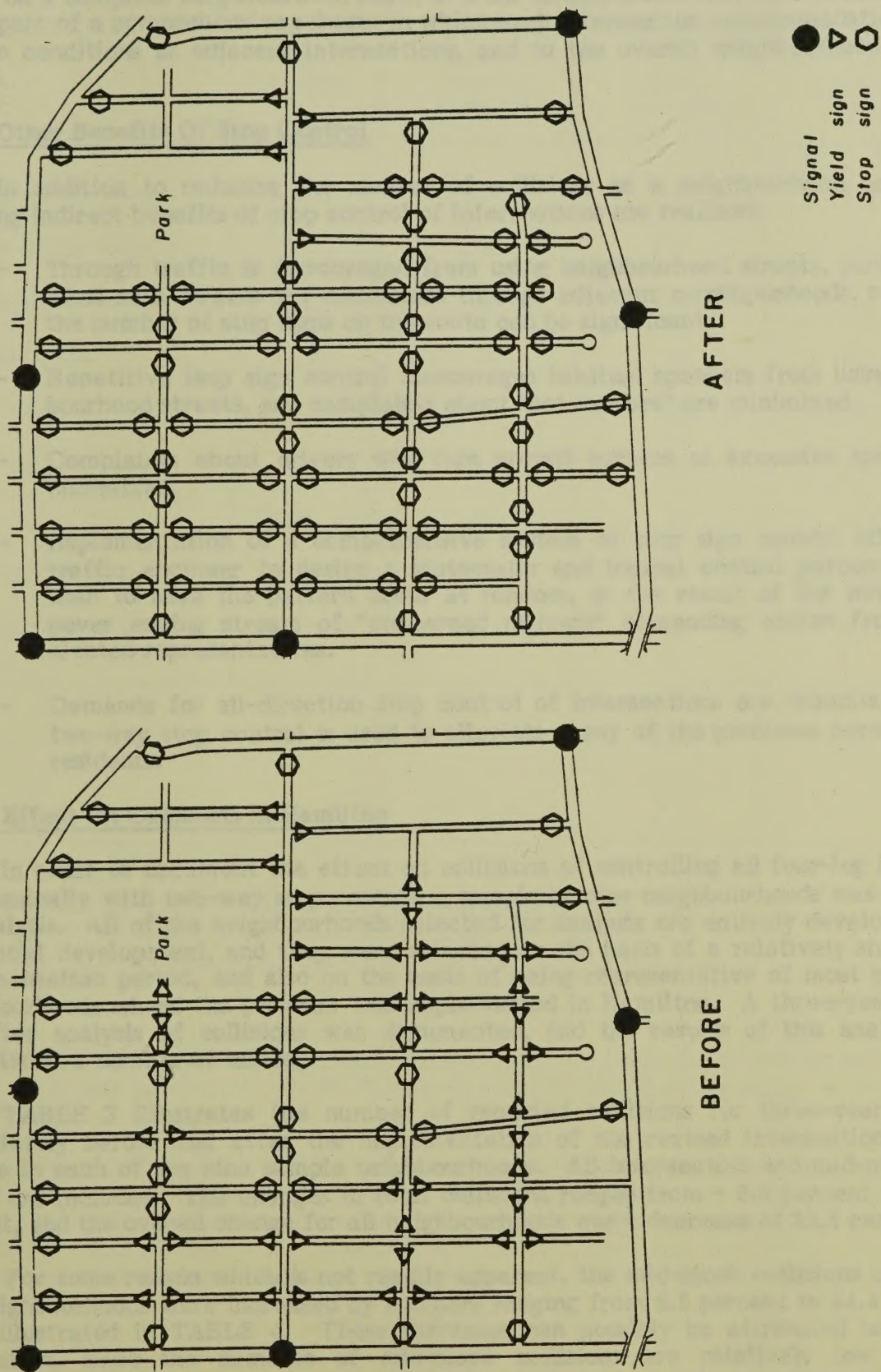


FIGURE 2 - TYPICAL CHANGES IN NEIGHBOURHOOD STOP SIGN CONTROL

A final "political" strategy is to present each neighbourhood to the decision makers on a complete neighbourhood basis, in order to emphasize that each recommendation is part of a comprehensive scheme in which each intersection recommendation is related to conditions at adjacent intersections, and to the overall neighbourhood control pattern.

3.3 Other Benefits Of Stop Control

In addition to reducing the number of collisions on a neighbourhood basis, the following indirect benefits of stop control of intersections are realized:

- Through traffic is discouraged from using neighbourhood streets, particularly when such streets are continuous through adjacent neighbourhoods, such that the number of stop signs on the route can be significant.
- Repetitive stop sign control discourages habitual speeders from using neighbourhood streets, and complaints about "hot rodders" are minimized.
- Complaints about drivers who turn around corners at excessive speeds are minimized.
- Implementation of a comprehensive system of stop sign control allows the traffic engineer to design a systematic and logical control pattern, rather than to have the pattern occur at random, as the result of the whims of a never ending stream of "concerned citizens" demanding action from their elected representatives.
- Demands for all-direction stop control of intersections are minimized when two-way stop control is used to alleviate many of the problems perceived by residents.

3.4 Effect On Collisions In Hamilton

In order to document the effect on collisions of controlling all four-leg intersections basically with two-way stop control, a sample of nine neighbourhoods was selected for analysis. All of the neighbourhoods selected for analysis are entirely developed with residential development, and they were selected on the basis of a relatively short term implementation period, and also on the basis of being representative of most of the 82 neighbourhoods where the program was implemented in Hamilton. A three-year before and after analysis of collisions was documented, and the results of this analysis are presented in a number of tables.

TABLE 3 illustrates the number of reported collisions for three-year periods immediately before and after the implementation of the revised intersection control scheme in each of the nine sample neighbourhoods. All intersection and mid-block collisions are included. The changes in total collisions ranged from + 9.5 percent to - 53.8 percent, and the overall change for all neighbourhoods was a decrease of 23.8 percent.

For some reason which is not readily apparent, the mid-block collisions in four of the neighbourhoods were increased by numbers ranging from 9.5 percent to 44.4 percent, as is illustrated in TABLE 4. These increases can possibly be attributed to random fluctuation, since the numbers of mid-block collisions are relatively low in each neighbourhood. The result of this factor is that the total collisions increased in two of the neighbourhoods, and decreased in the remaining seven neighbourhoods. Nonetheless, the total change in collision rate for mid-block locations was a decrease of 18.9 percent.

NEIGHBOURHOOD	YEAR SIGNS CHANGED	COLLISIONS BEFORE CHANGE (3 YEARS)	COLLISIONS AFTER CHANGE (3 YEARS)	CHANGE IN COLLISION RATE
Crown Point East	1977	155	91	- 41.3%
Crown Point West	1976	200	183	- 8.5%
Homeside	1978	198	129	- 34.8%
Normanhurst	1978	93	74	- 20.4%
Inch Park	1975	57	62	+ 8.8%
Hill Park	1978	44	26	- 40.9%
Balfour	1977/78	27	26	- 3.7%
Westcliffe East	1978	21	23	+ 9.5%
Westcliffe West	1976/78	26	12	- 53.8%
TOTAL		821	626	- 23.8%
TABLE III - COLLISION RATES IN NEIGHBOURHOODS AFTER INTERSECTION CONTROL IS CHANGED - TOTAL				

TABLE 5 illustrates that intersection collisions only decreased in each of the sample neighbourhoods, and the overall change for all neighbourhoods was a decrease of 28.8 percent.

TABLE 6 illustrates that for those intersections at which the intersection control was changed, reductions in the number of collisions ranged from 16.7 percent to 100 percent, and the overall change for all of the sample neighbourhoods was a decrease in collisions of 47.6 percent. An intersection control change was defined to be a change from no control or yield control to stop control, or a change in the direction of stop control.

NEIGHBOURHOOD	YEAR SIGNS CHANGED	COLLISIONS BEFORE CHANGE (3 YEARS)	COLLISIONS AFTER CHANGE (3 YEARS)	CHANGE IN COLLISION RATE
Crown Point East	1977	82	39	- 52.4%
Crown Point West	1976	97	108	+ 11.3%
Homeside	1978	104	51	- 50.9%
Normanhurst	1978	42	46	+ 9.5%
Inch Park	1975	27	39	+ 44.4%
Hill Park	1978	28	14	- 50.0%
Balfour	1977/78	15	15	--
Westcliffe East	1978	12	17	+ 41.6%
Westcliffe West	1976/78	11	10	- 9.0%
TOTAL		418	339	- 18.9%
TABLE 4 - COLLISION RATES IN NEIGHBOURHOODS AFTER INTERSECTION CONTROL IS CHANGED - MID-BLOCK				

4. WIDENING AND CHANNELIZATION OF ARTERIAL STREET INTERSECTIONS

4.1 The Concept

Most municipalities have adopted modern design criteria for arterial street intersections, which involve the provision of off-set left turn lanes and of raised median islands. The off-setting of the left turn lanes permits left turning motorists to see past the left turning vehicles in the opposing direction, such that on-coming through traffic is visible and left turn movements can be made in relative safety. The raised median islands serve primarily to physically prohibit left turn and crossing movements on the approaches to the intersection, and therefore to minimize conflicting vehicular paths in these critical areas.

NEIGHBOURHOOD	YEAR SIGNS CHANGED	COLLISIONS BEFORE CHANGE (3 YEARS)	COLLISIONS AFTER CHANGE (3 YEARS)	CHANGE IN COLLISION RATE
Crown Point East	1977	73	52	- 28.8%
Crown Point West	1976	103	75	- 27.2%
Homeside	1978	94	78	- 17.0%
Normanhurst	1978	51	28	- 45.1%
Inch Park	1975	30	23	- 23.3%
Hill Park	1978	16	12	- 25.0%
Balfour	1977/78	12	11	- 8.3%
Westcliffe East	1978	9	6	- 33.3%
Westcliffe West	1976/78	15	2	- 86.7%
TOTAL		403	287	- 28.8%
TABLE 5 - COLLISION RATES IN NEIGHBOURHOODS AFTER INTERSECTION CONTROL IS CHANGED - INTERSECTIONS				

In many cases, intersection channelizations are performed primarily to increase vehicular capacity. However, the program in Hamilton has placed equal emphasis on the reduction of intersection collisions, and the priority for reconstruction has, in many cases, been determined primarily on the basis of this factor.

The standard design utilized in Hamilton is illustrated in FIGURE 3. The total pavement width, including the 1.5 metre wide centre median, is 19 metres for four lane roads and 26 metres for six lane roads. The standard curb radii are 15 metres, although in some cases on non-truck routes, the radii have been reduced to 12 metres. The length of the raised centre median is normally a minimum of 30 metres, although in many cases, it is considerably longer, particularly on commercial streets where major driveway movements must be restricted.

NEIGHBOURHOOD	YEAR SIGNS CHANGED	COLLISIONS BEFORE CHANGE (3 YEARS)	COLLISIONS AFTER CHANGE (3 YEARS)	CHANGE IN COLLISION RATE
Crown Point East	1977	60	25	- 58.3%
Crown Point West	1976	84	46	- 45.2%
Homeside	1978	59	40	- 32.2%
Normanhurst	1978	22	13	- 40.9%
Inch Park	1975	8	2	- 75.0%
Hill Park	1978	12	10	- 16.7%
Balfour	1977/78	6	3	- 50.0%
Westcliffe East	1978	5	1	- 80.0%
Westcliffe West	1976/78	11	0	- 100.0%
TOTAL		267	140	- 47.6%

TABLE 6 - COLLISION RATES IN NEIGHBOURHOODS AFTER INTERSECTION CONTROL IS CHANGED - CHANGED INTERSECTIONS

The Hamilton program of channelization has been in progress for almost twenty years, and at the present time approximately 51 intersections have been partially or completely constructed in this design, as is illustrated in FIGURE 4. An additional 40 or 50 intersections have been channelized entirely or in part by pavement marking, but none of these are included in the statistical analysis.

4.2 Implementation Strategies

The basic implementation strategies for channelization of arterial intersections are really policies rather than strategies.

The first policy is to have the decision makers adopt a standard intersection design, similar to the one illustrated in FIGURE 3. Statistical data may be needed to document the increased capacity and safety which this type of design provides.

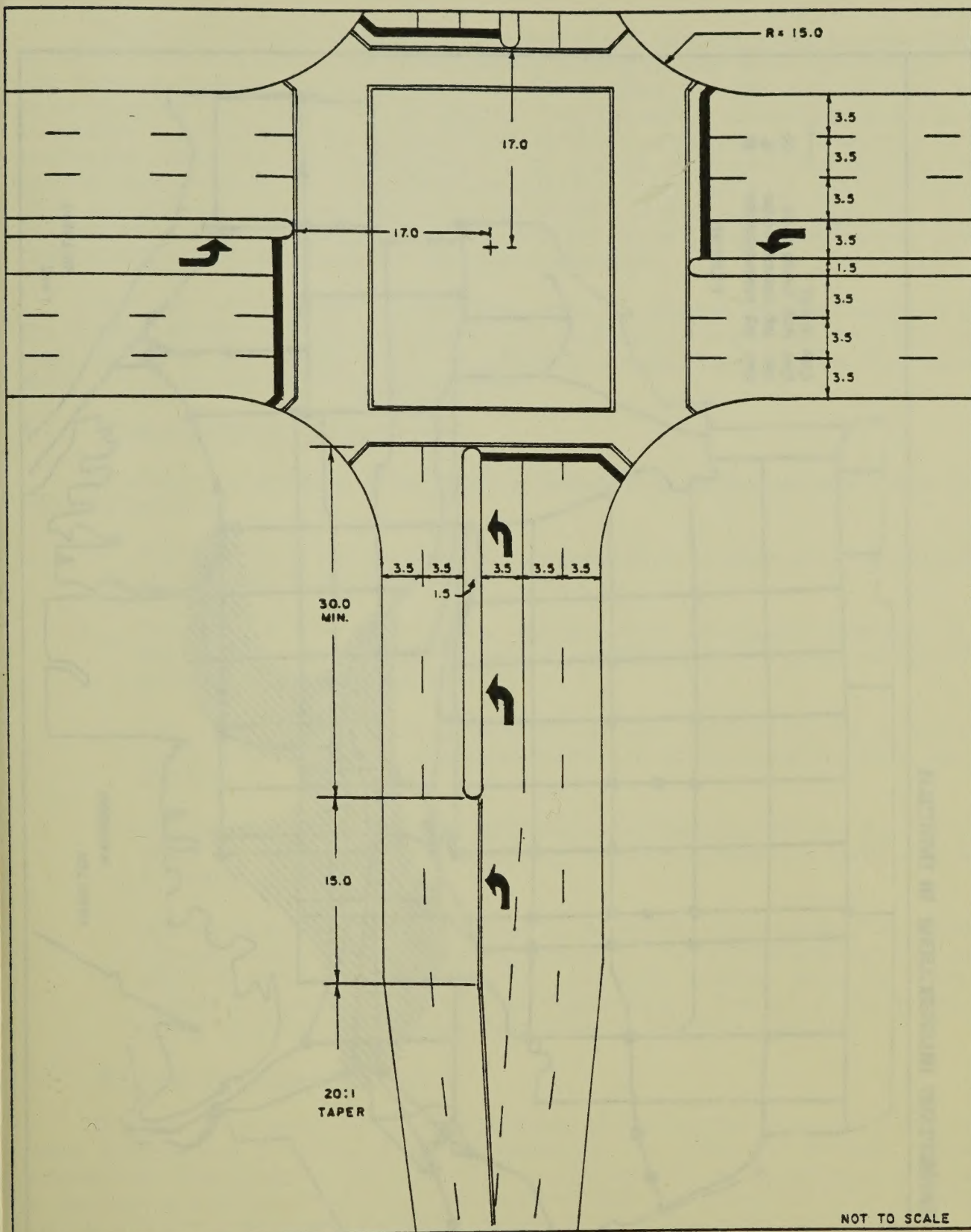
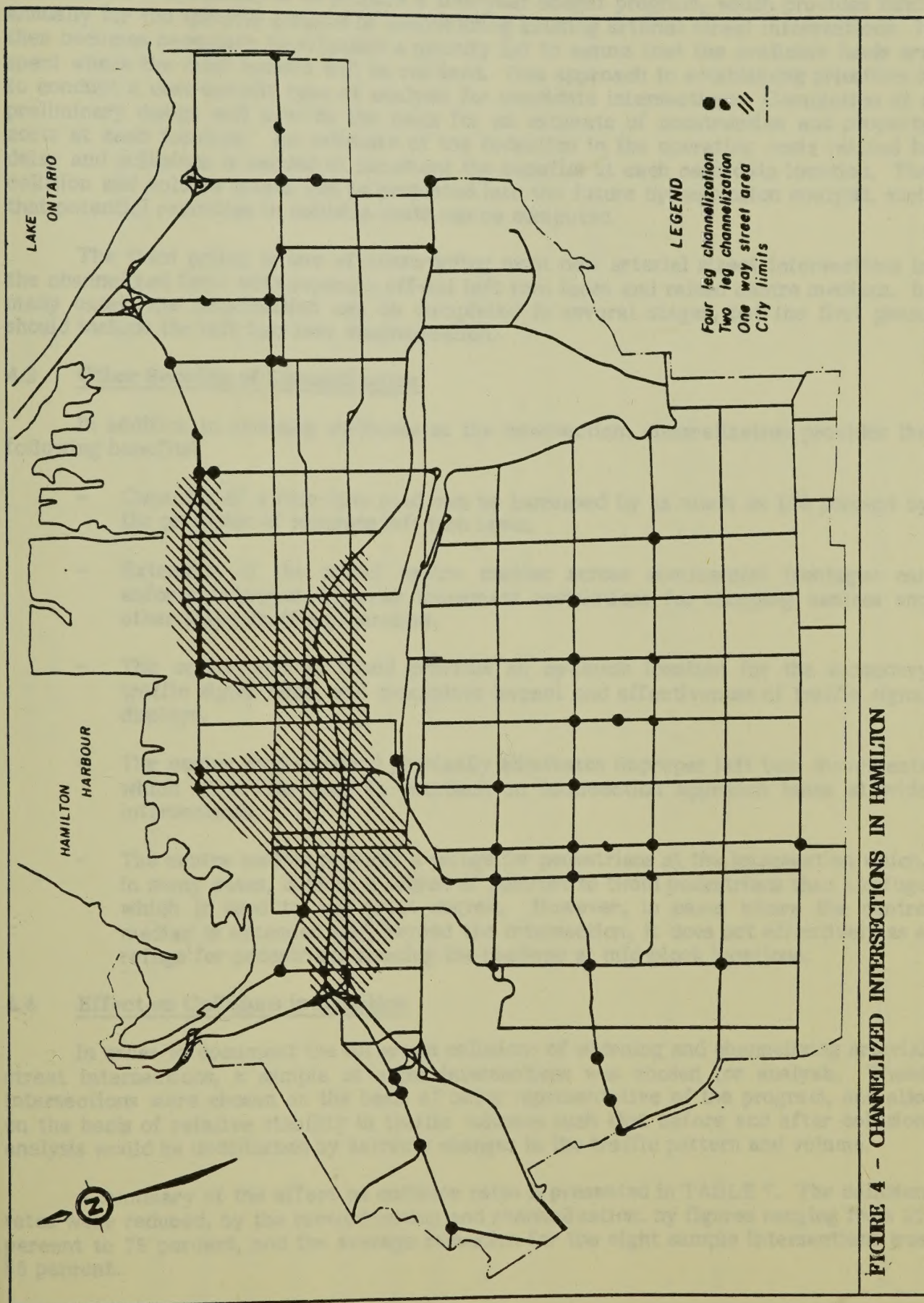


FIGURE 3 - STANDARD INTERSECTION CHANNELIZATION DESIGN



The second policy is to prepare a five-year budget program, which provides funds annually for the specific purpose of channelizing existing arterial street intersections. It then becomes necessary to establish a priority list to assure that the available funds are spent where the most benefit will be realized. One approach to establishing priorities is to conduct a cost-benefit type of analysis for candidate intersections. Completion of a preliminary design will provide the basis for an estimate of construction and property costs at each location. An estimate of the reduction in the operating costs related to delay and collisions is needed to document the benefits at each candidate location. The collision and volume trends can be projected into the future by regression analysis, such that potential reduction in collision costs can be computed.

The third policy is one of constructing most new arterial street intersections in the channelized form with separate off-set left turn lanes and raised centre medians. In many cases, the construction can be completed in several stages, but the first phase should include the left turn lane channelization.

4.3 Other Benefits of Channelization

In addition to reducing collisions at the intersection, channelization provides the following benefits:

- Capacity of a four-lane road can be increased by as much as 100 percent by the provision of separate left turn lanes.
- Extension of the raised centre median across commercial frontages can enforce intended driveway movement restrictions for shopping centres and other major traffic generators.
- The centre median island provides an optimum location for the secondary traffic signal head, and maximizes impact and effectiveness of traffic signal displays.
- The centre median island physically eliminates improper left turn movements which otherwise tend to encroach on intersection approach lanes at wide intersections.
- The centre median provides a refuge for pedestrians at the intersection which, in many cases, is more a source of comfort to timid pedestrians than a refuge which is used to any great degree. However, in cases where the centre median is extended well beyond the intersection, it does act effectively as a refuge for pedestrians crossing the roadway at mid-block locations.

4.4 Effect on Collisions in Hamilton

In order to document the effect on collisions of widening and channelizing arterial street intersections, a sample of eight intersections was chosen for analysis. These intersections were chosen on the basis of being representative of the program, and also on the basis of relative stability in traffic volumes such that before and after collision analysis would be undisturbed by extreme changes in the traffic pattern and volume.

A summary of the effect on collision rates is presented in TABLE 7. The collision rates were reduced, by the reconstruction and channelization, by figures ranging from 32 percent to 75 percent, and the average reduction for the eight sample intersections was 55 percent.

INTERSECTION	YEAR OF RECONST.	BEFORE (3 YEARS)			AFTER (3 YEARS)			CHANGE IN COLLISION RATE
		COLLISIONS	AWDT VOLUME	COLLISION RATE *	COLLISIONS	AWDT VOLUME	COLLISION RATE *	
Mohawk & U. James	1968	80	29,870	2.55	47	35,130	1.28	- 50%
Mohawk & W. 5th	1979	71	28,960	2.34	12 **	28,960	0.59 **	- 75%
Mohawk & U. Wellington	1978	66	25,820	2.44	19	29,020	0.62	- 75%
Fennell & U. James	1968/69	42	23,160	1.73	31	27,960	1.06	- 39%
Fennell & W. 5th	1971	54	25,160	2.05	42	28,880	1.39	- 32%
Fennell & U. Wellington	1977	56	26,440	2.02	20	28,500	0.67	- 67%
Barton & Parkdale	1972/78	51	30,670	1.59	45	40,000	1.07	- 33%
Limeridge & U. James	1979	47	23,270	1.93	16 **	25,840	0.59 **	- 69%
AVERAGE								- 55%
* Collision Rate per Million Vehicles Entering = $\frac{\text{accidents per year} \times 2,860}{\text{A.W.D.T. entering intersection}}$ ** 2 years data only								
TABLE 7 - COLLISION RATES AT ARTERIAL INTERSECTIONS AFTER CHANNELIZATION								

5. PROVISION OF TWO-WAY LEFT TURN LANES

5.1 The Concept

The two-way left turn lane is a centre lane of a roadway which is designated for left turn movements only, throughout its length, by signing and pavement marking. The left turning motorist is permitted to enter the lane only at a point immediately ahead of the location at which a left turn to a public highway or a driveway is to be made.

In Hamilton, the width of the two-way left turn lane is 5 metres, as is illustrated in FIGURE 5. Standard pavement markings, as specified in the Manual of Uniform Traffic Control Devices for Canada, are used. Overhead signing is provided on span wires at intervals of approximately 100 metres, and is supplemented by pavement arrows. The general criterion is that overhead signs should be placed in each mid-block section such that a motorist who has turned onto the street from an intersecting street will be faced by a clearly visible overhead sign assembly.

The 5 metre width is used because there are frequently sections, where conventional one direction left turn lanes with raised 1.5 metre medians are incorporated, such as at signalized intersections, and this width is appropriate to both types of design. This also provides the flexibility to change various sections from two-way operation to one-way operation, and vice-versa, in the event that changing conditions require a revision in the design.

The use of two-way left turn lanes is a relatively new innovation in Hamilton, and to date a total of only 3.4 kilometres of street have been provided with this type of design.

5.2 Implementation Strategies

The principle implementation strategy is the adoption of a policy that two-way left turn lanes will be used on major arterial streets in locations where left turn movements are causing significant congestion or accident problems, but the prohibition of left turn and crossing movements, by a raised centre median, is not justified. In many locations, a combination of raised barrier median sections and two-way left turn lane sections will provide an optimum design.

5.3 Other Benefits of Two-Way Left Turn Lanes

In addition to reducing collisions, the following benefits of two-way left turn lanes are realized:

- Capacity of a four-lane road can be increased by as much as 100 percent.
- Traffic flow is smoothed, since the two-way left turn lane is used as a deceleration lane for left turning vehicles.
- The two-way left turn lane also serves as a refuge and acceleration lane for left turn movements onto the street from intersecting streets and from driveways, thereby increasing capacity and reducing delay for these movements.

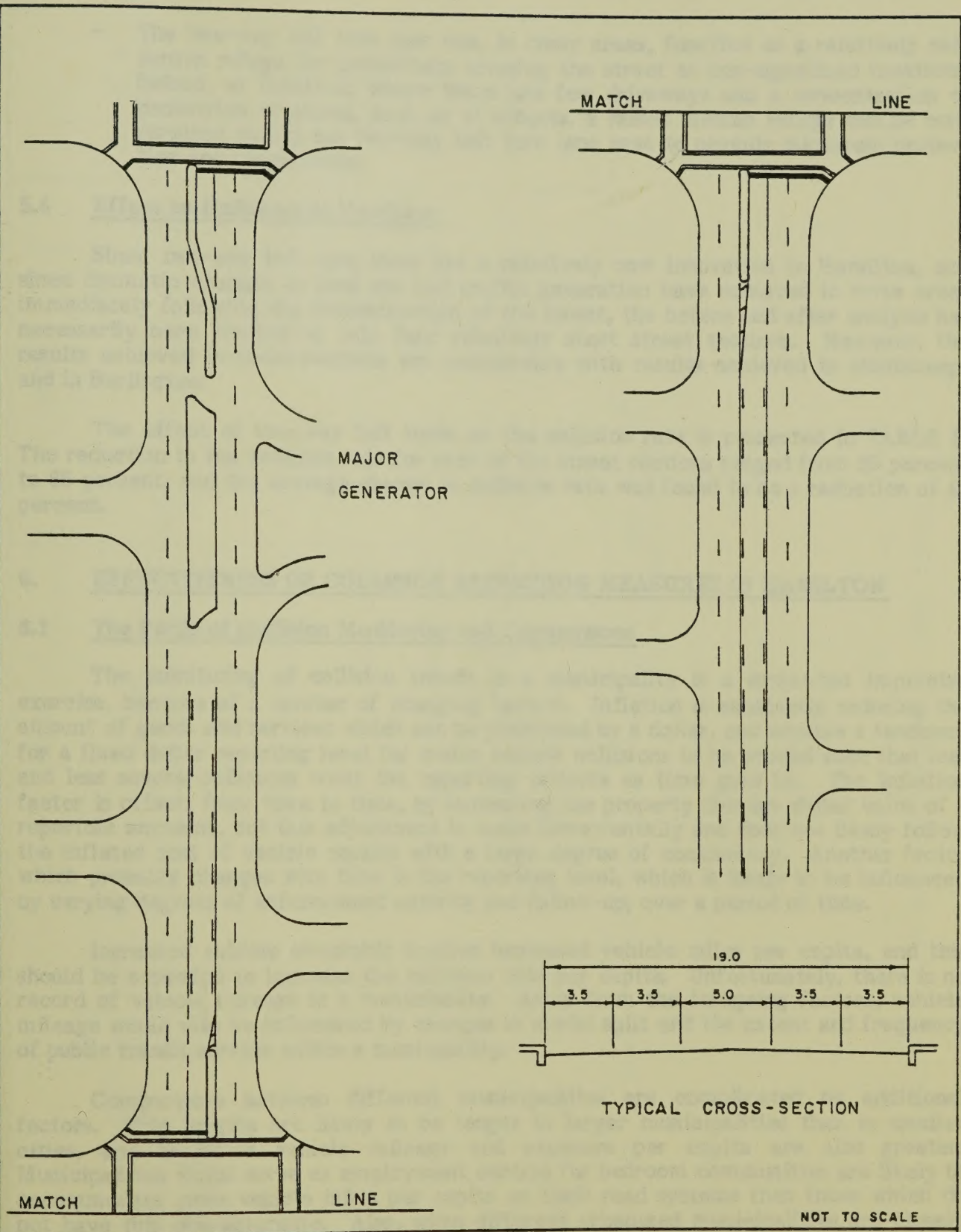


FIGURE 5 - DESIGN OF TWO-WAY LEFT TURN LANE

- The two-way left turn lane can, in many areas, function as a relatively safe centre refuge for pedestrians crossing the street at non-signalized locations. Indeed, at locations where there are few driveways and a concentration of pedestrian crossings, such as at schools, a raised median refuge can be constructed within the two-way left turn lane area to provide maximum protection and convenience.

5.4 Effect on Collisions in Hamilton

Since two-way left turn lanes are a relatively new innovation in Hamilton, and since dramatic changes in land use and traffic generation have occurred in some areas immediately following the reconstruction of the street, the before and after analysis has necessarily been limited to only four relatively short street sections. However, the results achieved in these sections are comparable with results achieved in Mississauga and in Burlington.

The effect of two-way left turns on the collision rate is presented in TABLE 8. The reduction in the collision rate for each of the street sections ranged from 29 percent to 65 percent, and the average change in collision rate was found to be a reduction of 49 percent.

6. EFFECTIVENESS OF COLLISION REDUCTION MEASURES IN HAMILTON

6.1 The Perils of Collision Monitoring and Comparisons

The monitoring of collision trends in a municipality is a somewhat imprecise exercise, because of a number of changing factors. Inflation is constantly reducing the amount of goods and services which can be purchased by a dollar, and creates a tendency for a fixed dollar reporting level for motor vehicle collisions to be eroded such that less and less severe collisions meet the reporting criteria as time goes by. The inflation factor is offset, from time to time, by increasing the property damage dollar value of a reportable accident, but this adjustment is made incrementally and does not likely follow the inflated cost of vehicle repairs with a large degree of consistency. Another factor which probably changes with time is the reporting level, which is likely to be influenced by varying degrees of enforcement activity and follow-up, over a period of time.

Increased vehicle ownership implies increased vehicle miles per capita, and this should be expected to increase the collision rate per capita. Unfortunately, there is no record of vehicle mileage in a municipality. Aside from the foregoing factors, vehicle mileage would also be influenced by changes in modal split and the extent and frequency of public transit service within a municipality.

Comparisons between different municipalities are complicated by additional factors. Trip lengths are likely to be longer in larger municipalities than in smaller cities, and therefore vehicle mileage and exposure per capita are also greater. Municipalities which serve as employment centres for bedroom communities are likely to accommodate more vehicle miles per capita on their road systems than those which do not have this characteristic. Also, when different urbanized municipalities are closely spaced, there is likely to be more through traffic on municipal streets than normal, which contributes to the collision rate which is attributed to that particular community.

In spite of the perils and difficulties presented by the above-mentioned factors, it is instructive and worthwhile to monitor collision rates in municipalities, and to make comparisons between municipalities.

STREET	LENGTH (km)	YEAR TWO-WAY LEFT TURN LANE BUILT	BEFORE			AFTER			CHANGE IN COLLISION RATE		
			YEARS	ACCS.	AWDT VOLUME	ACC. RATE*	YEARS	ACCS.		AWDT VOLUME	ACC. RATE*
Upper James											
- Fennell to McElroy	0.5	1980	3	49	22,390	4.17	1	12	23,050	2.98	- 29%
- McElroy to Mohawk	0.5	1980	3	63	22,560	5.32	1	11	22,030	2.86	- 46%
- Mohawk to Hester	0.4	1979	3	114	24,190	11.23	2	32	22,470	5.09	- 55%
- Hester to Limeridge	0.6	1979	3	100	19,900	7.98	2	23	19,400	2.83	- 65%
AVERAGE										- 49%	
* Collision Rate per Million Vehicle Kilanetres = $\frac{\text{accidents per year} \times 2,860}{\text{distance (km)} \times \text{A.W.D.T.}}$											

TABLE 8	- COLLISION RATES WITH TWO-WAY LEFT TURN LANES
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TABLE 8 - COLLISION RATES WITH TWO-WAY LEFT TURN LANES

6.2 The Collision Trend in Hamilton

After considering alternative parameters for monitoring collision rates in Hamilton, the writer has concluded that the best index for a long term comparison is the collision rate per capita, for all reported accidents. This index is presented graphically in FIGURE 6. Also indicated is the time period when the four specific collision reduction measures were being implemented.

The collision rate rose dramatically in the years following 1951, until the implementation of the first phase of the one-way street system in 1956. The first phase applied to major streets in and near the central business district, and had a significant impact on the city wide collision rate.

A second decided downturn occurred in 1966, which has been sustained to the present time. While the four specific countermeasures highlighted in this paper do not explain why the downturn began in 1966, since only one of the four had been begun at that time, the results achieved by these countermeasures do explain why the downturn has been sustained to the present date. It must be concluded that these four countermeasures, in combination with other activities, have had a very positive effect on reducing the collision rate in Hamilton.

6.3 Comparisons With Other Municipalities

The difficulties of maintaining statistically valid collision data over a period of time, for a single municipality, are compounded when attempts are made to compare conditions in different municipalities and in different countries. For this reason, the best indicator is probably the fatality rate, since this is likely to be consistently reported by all jurisdictions in North America.

The fatality rate, based upon population and upon vehicle registration, is reported annually for most major cities in North America, in the publication "Accident Facts", by the National Safety Council of the United States. The 1981 Edition reported on 1980 statistics, and that tabular summary is presented in TABLE 9, for reporting Canadian cities, and for American cities in the population range of 200,000 to 350,000 persons. The table indicates that the Hamilton population rate of 7.4 fatalities per 100,000 population compared favourably with that of reporting Canadian cities, and was approximately one-half the average of 14.2 for all American cities in the range. A similar favourable relationship existed for the vehicle registration rate, which was 1.3 for Hamilton, and an average of 2.0 for other cities in the range. Moreover, this relationship has been consistent in recent years.

It must be concluded that Hamilton is one of the safest cities in North America for the pedestrian and motoring public.

7. CONCLUSIONS

Collision fatality statistics for North American cities, prepared by the American National Safety Council, confirm that Hamilton is one of the safest cities in North America for pedestrians and motorists. The collision rate in Hamilton has decreased steadily since 1965, and the application of the four collision reduction measures discussed in this paper have been a significant factor. Removal of parking from arterial streets has reduced the collision rate by 37 percent. Control of local street intersections by stop signs has reduced all neighbourhood collisions by 24 percent. Channelization of arterial

YEARS OF MAJOR COUNTERMEASURES PROGRAM

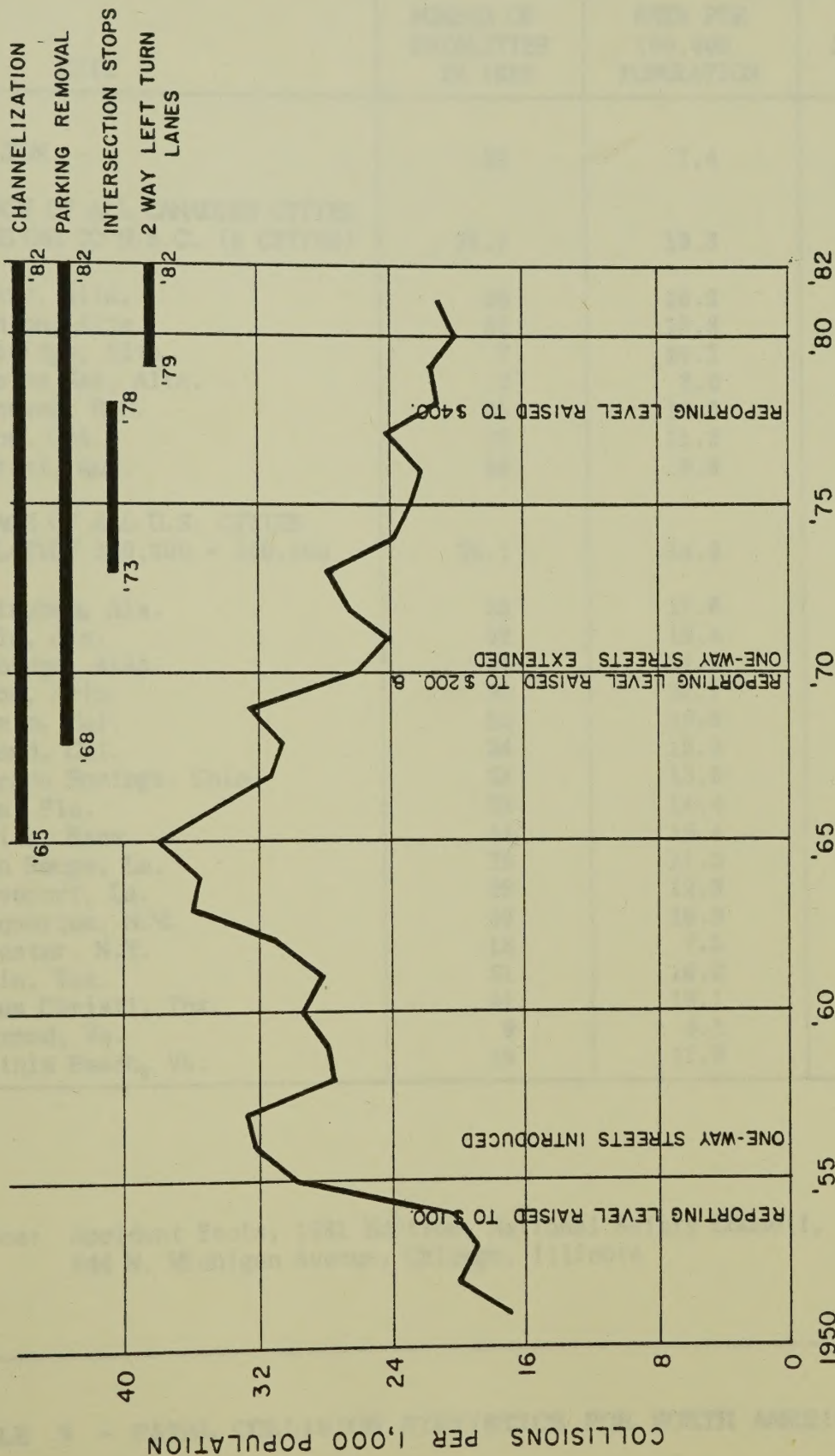


FIGURE 6 - CORRELATION OF COUNTERMEASURES PROGRAM WITH COLLISION RATE

CITY	NUMBER OF FATALITIES IN 1980	RATE PER 100,000 POPULATION	RATE PER 10,000 REG. VEHICLES
HAMILTON	22	7.4	1.3
AVERAGE OF ALL CANADIAN CITIES REPORTING TO N.S.C. (8 CITIES)	38.1	10.6	2.5
Calgary, Alta.	56	16.9	3.8
Edmonton, Alta.	52	13.8	3.2
Lethbridge, Alta.	7	19.1	4.1
Medicine Hat, Alta.	2	8.0	1.8
Vancouver, B.C.	60	14.6	2.4
London, Ont.	22	11.3	3.0
Montreal, Que.	84	6.9	2.1
AVERAGE OF ALL U.S. CITIES POPULATION 200,000 - 350,000	36.1	14.2	2.0
Birmingham, Ala.	38	13.6	1.8
Mobile, Ala.	32	15.4	2.9
Anchorage, Alas.	24	11.9	1.3
Tucson, Ariz.	95	28.7	4.4
Anaheim, Cal.	22	10.6	1.3
Oakland, Cal.	34	10.0	1.7
Colorado Springs, Colo.	28	13.5	1.8
Tampa, Fla.	38	14.4	1.6
Wichita, Kans.	44	16.4	2.0
Baton Rouge, La.	35	11.3	2.5
Shreveport, La.	26	12.9	1.8
Albuquerque, N.M.	50	16.9	2.1
Rochester, N.Y.	18	7.5	1.0
Austin, Tex.	51	16.0	2.0
Corpus Christi, Tex.	41	19.1	2.6
Richmond, Va.	9	4.1	0.6
Virginia Beach, Va.	29	11.8	2.0

Source: Accident Facts, 1981 Edition, National Safety Council,
444 N. Michigan Avenue, Chicago, Illinois

TABLE 9 - FATAL COLLISION STATISTICS FOR NORTH AMERICAN CITIES

intersections has reduced the collision rate by 55 percent, and two-way left turn lanes have reduced the collision rate by 49 percent.

8. ACKNOWLEDGEMENTS

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